Mapping *in situ* Apparent Optical Properties using Coastal Slocum Webb Gliders

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Grant Number: N000140610327
http://marine.rutgers.edu/cool/auvs/

LONG-TERM GOALS

Develop and demonstrate in a collaborative Mid-Atlantic Bight test-bed a coupled observation and data assimilative modeling capability that contributes to our understanding of continental shelf processes, provides societal benefits, and is relocatable worldwide in both collaborative and non-collaborative environments. Our approach will leverage the complementary capabilities of academic, industry and government groups through NOPP-style partnerships to develop new satellite remote sensing algorithms, new HF radar hardware and processing software, and new autonomous underwater vehicles and sensors for subsurface adaptive sampling. We will use the new technologies to sustain a continuous long-term presence on the New Jersey Shelf with enhanced coverage during an ongoing series of scientific process studies that includes advanced data assimilation in coupled atmosphere/ocean physical, biological, biogeochemical, and sediment transport models.

OBJECTIVES

Year 1 Objectives:

1) Prepare and deploy a fleet of gliders to occupy a series of closely spaced repeat transects across the shelf-slope front within and around the SW06 mooring array, maintaining a continuous presence for the full duration of the joint experiment.
2) Distribute the glider CTD datasets in near real-time to the ocean modeling community for assimilation by forecast models.
3) Use the full resources of the New Jersey Shelf Coastal Observatory to support real-time shipboard operations in the SW06 region, emphasizing the detection and characterization of internal waves during the first half of the experiment and resolution of the submesoscale variability of the shelf-slope front for acoustics applications during the second half.

Year 2 Objectives:

1) Actively participate with other SW06 scientists in the collaborative post-analysis of the SW06 dataset.
2) Use the SW06 dataset as the starting point for a Rutgers student's Ph.D. thesis.

Importance: The New Jersey Shelf Coastal Observatory has already demonstrated its ability to provide a critical spatial and temporal context for multi-ship and mooring array based scientific process studies of the Hudson River plume on the inner shelf. Use of the same Coastal Observatory in the SW06 process studies on the outer shelf provides a similar context to help optimize the extensive

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2006**	2. REPORT TYPE	3. DATES COVERED **00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE **Mapping in situ Apparent Optical Properties using Coastal Slocum Webb Gliders**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Rutgers University,Coastal Ocean Observation Lab,71 Dudley Road,New Brunswick,NJ,08901**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ONR and academic investments while simultaneously presenting new challenges to the observatory. New challenges include spinning up and then sustaining a large coordinated fleet of gliders for unprecedented coverage of the outer NJ shelf for a duration over twice the typical battery life of a shallow glider mission, and providing environmental guidance to a distributed fleet of research vessels outside of shore-based computer communication networks.

APPROACH

Ship to shore computer communications were enabled by the WHOI HiSeasNet using the Knorr as the offshore hub with broadband wireless connections to other vessels within range. WHOI ExView provided a logistics interface for discussions and data product exchange supporting a distributed network with intermittent connectivity. The Coastal Ocean Observation Lab was restructured for enhanced observatory operations by forming operational teams consisting of a 5 person glider operations team, one operations person each for satellites, CODAR, and weather forecasting, and a 4 person data analysis team. The gliderteam successfully dealt with the compact delivery schedule that resulted in the majority of the gliders running their first check out mission during the experiment. Glider operations total 17 deployments sampling over 6,400 km and acquiring over 50,000 CTD casts. The data analysis team produced a real-time quality controlled Glider CTD dataset that was made available to modelers for assimilation, accepted data from other SW06 participants for visualization, and produced a daily environmental report and storm alerts made available to shipboard crews via ExView over a 3 month period.

WORK COMPLETED

The science bays with the OCR-500 radiometers are almost finished being constructed. The existing science bays originally included two WetLabs Eco-Pucks and the Wetlabs Scattering-Attenuation Meter (SAM). This science bay had to be modified. First, we have removed the existing SAMs given issues of leaks in the instrument which sufficiently impact on buoyancy to endanger the platform. Webb Research has been anchoring the fabrication of a new payload bay and modification of the Glider science computer software. The Slocum Coastal glider has been designed with a removable 10 inch long payload bay section located in the middle of the hull length. The Webb Research will integrate the radiometer will be in an upward looking direction to complement the SAM sensing heads looking in a sideways orientation with backscatter pucks facing the sea floor. Secondarily the OCR radiometers (Fig. 1) will be mounted on top of the instrument payload of the glider at a thirty degree angle (Fig. 2). The OCR systems we purchased measure downwelling at 412.2, 442.4, 490.6, and 664.8 nm. The OCR systems have been modified so that they are the same size as WetLab backscatter pucks which makes integration more straight forward then integrating a hyperspectral Minispec.

Fig. 1. The OCR-500 multi-spectral radiometer that will be deployed in optical Webb Gliders.

In addition to the physical hardware integration, power management and data handling will be addressed. Software modifications will be made to the onboard payload computer to collect the data stream and merge it with the glider flightdata set that is normally transmitted via Iridium or RF modem. The onboard science computer onboard the Glider will parse out appropriate optical data for Naval system performance models in order to minimize the time required for real-time data transfers. Other software efforts will focus on deriving spectral diffuse attenuation coefficients from the irradiance profiles collected by the glider. Our initial plan is to use data from the gliders downward trajectories to calculate the downwelling diffuse attenuation coefficient. This will provide sufficient data for providing high resolution cross sections. Currently, on a single battery pack in a glider outfitted with optics can collect over 4000 vertical profiles. We hope to have the initial science bays available for testing by November 2006. This will allow a full season of testing prior to the OASIS field season in the Fall of 2007.

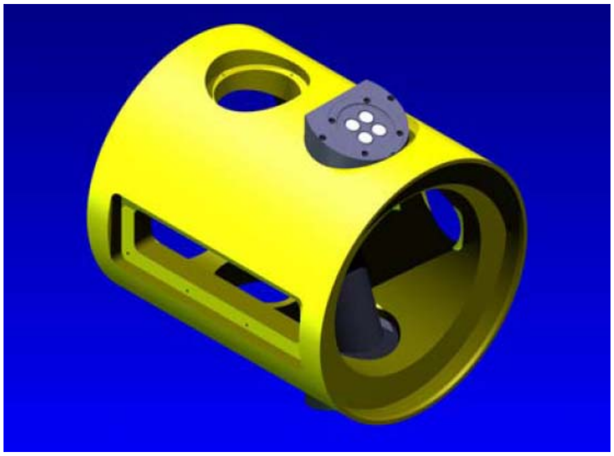

Fig. 2. The orientation of the radiometer in the glider as designed for a French Webb glider. Recent design upgrades will make the sensor be flush with the outer hull of the Webb Glider.

RESULTS

Results from the recent RIMPAC indicate the AOP gliders will have great utility. First, the SAM system has had moderate success during deployments especially in oligotrophic waters, and any data that complements the backscatter data to constrain the EODES performance prediction system will be useful. This is especially true as the backscatter instruments have sufficient sensitivity and system performance models have demonstrated success. The success will improve when combined with the derived downwelling diffuse attenuation coefficient. The first tests will be conducted in Fall 2006.

IMPACT/APPLICATIONS

The demonstration that gliders are robust tools capable of maintianing a sustained presence in the oceans (Fig. 3) have resulted in high naval interest. Characterizing *in situ* water turbidity is critical to numerous naval operations. In particular when water column turbidity impacts the efficacy of sensors that use optical measurements for a variety of purposes. These optical measurements are used to improve laser detection of mines and prediction of the operational detection horizon for bioluminescence. The ability to deploy and allow covert insertion of assetts “over the horizon” will provide a critical assett for planning mine counter measures. The turbidity data has been demonstrated in recent MIREM and RIMPAC field efforts to provide useful data to mission planners providing reconsaince data from the denied areas. The addition of optical properties to the gliders has expanded the utility of gliders for mine counter measures in addition to the anitsubmairne applications demonstrated during the Sharem field efforts.

TRANSITIONS

The success of the gliders in a variety of the field exercises have resulted in the active procurement of the gliders for the fleet. The assets will likely become assets of both the NAVOCEANO and the fleet. Recent plans call for 300 gliders to be purchased. One of the major advantages of the Webb Glider is that it provides a modular platform. The development of an optical science bay that can support mine counter measures will thus be of great utility to evolving fleet of Naval gliders. In addition to the actual platforms, the existing Glider processing software developed by Rutgers and WRC are being transitioned to NAVOCEANO. The software includes the processing and formatting of the data to facilitate the data assimilation into operational naval models.

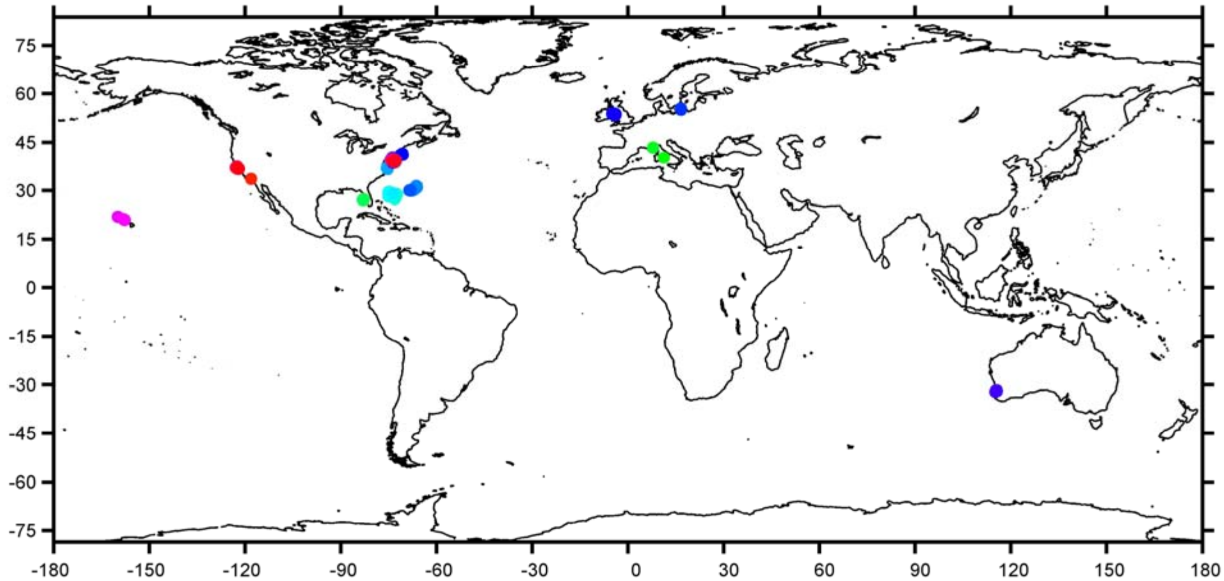

Fig. 3. The deployments of Rutgers world-wide since October 2003. This map does not include some locations in the Pacific.

RELATED PROJECTS

This project leverages and complements several ONR efforts. These gliders will play a major role in the ONR sponsored OASIS field program in fall 2007. That effort will assess the role in storms in regulating the sediment resuspension and transport processes in the coastal ocean. The AOP gliders will provide the spatial context of the time series collected by the Eulerian assets to be deployed at the Martha Vineyard's Cabled Observatory. Developing the optical capability for gliders will directly benefit a recently funded Major University Research Initiative (MURI) which will develop a data assimilative physical-optical modeling-observation system consisting of an ensemble of optical models of varying complexity in order 1) to improve our predictive skill for forecasting ocean color and 2) improve physical models by using ocean color to discriminate hydrographic features not detected using traditional data streams. This MURI will study the regulation of ocean color for a broad western boundary continental shelf with a specific focus on regions of high optical variability (fronts), which coincide with regions of high acoustic uncertainty. The development of the optical gliders will directly benefit this effort.

PUBLICATIONS

One publication has been submitted and is currently under review. The manuscript was submitted to the Journal of Underwater Robotics.

Schofield, **O**., Kohut, J., Aragon, D., Creed, L., Haldeman, C., Kerfoot, J., Roarty, H., Jones, C., Webb, D., Glenn, S. M. Sloccum Gliders: Robust and ready. Journal of Underwater Robotics (submitted)